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National Aerospace Laboratory NLR

AMS Tracker Thermal Control Subsystem

QM FM Heat eXchanger orbital welding Procedure

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Document change log

Change Ref.	*Section(s)*	*Issue 1*
-	all	Initial issue
		Issue 2
	Section 1, section 4, , section 10, procedure sheets	Pre-weld instead of post weld used for sample during the
	Table 7-1	Explanation NDE testing added below table
	Procedure sheets	Section titles changed

Summary

This document describes the Heat exchanger orbital welding procedure. The content includes the step 15 requested from the overall sequence of the HX manufacturing, as described in RD-2.

2. Cut soldering sheets in correct shape
3. Vacuum brazing stack of plates
4. Cover all entrances to avoid particle contamination
5. Measure the dimensions of the soldered stack of plates
6. Turning and machining of stack of plates to final dimensions
7. Perform He-leak test on stack of plates AMSTR-NLR-PR-053
8. Clean & cleaning check HX parts (stack of plates on outside, and container part) AMSTR-NLR-PR-056
9. Vacuum brazing (lower temperature as previous brazing) stack of plates to housing
10. Visual inspection after brazing on cleanliness AMSTR-NLR-PR-056
11. He-leak test to check stack to container solder AMSTR-NLR-PR-053
12. Visual inspection on cleanliness AMSTR-NLR-PR-056
13. Clean storage of brazed assembly AMSTR-NLR-PR-056
14. Cleaning before welding AMSTR-NLR-PR-056
    a. Cleaning check on combined brazed assembly
    b. Clean & cleaning piece 13.1 prior to welding
15. **Weld HX orbital welding according to AMSTR-NLR-PR-54**
16. He leak test check solder connection of the stacked plates AMSTR-NLR-PR-053
17. Turn the HX container with grooves for the start-up wire heater installation
18. He leak test container, Proof pressure test, He-leak to check weld leak tightness and verify proof pressure, AMSTR-NLR-PR-053 issue 2

Contents

(47 pages in total)

1 Scope of the document

The procedure in this document describes the weld procedure for the HX. It describes the following steps

- Weld qualification prior to assembly
  - Identification of optimum weld parameters
  - Weld qualification
- Weld re-qualification (if necessary)
- Weld procedure during assembly
  - Pre-weld
  - Flight welding

The objective of the test is to verify the HX welds fulfil the NASA weld requirements and provide the safety verification documentation.

2 References documents

	Title	Number	Date
RD-1	TTCS Heat eXchanger Bread Board Model Test Report	TTCS-NLR-TN-042-Iss01	September 2005
RD-2	TTCS Heat eXchanger design Report	AMSTR-NLR-TN-053 issue 1.0	February 2007
RD-3	TTCS Requirements Verification Matrix FM H/W	AMSTR-NLR-PL-02 Issue 1.0	April 2007
RD-4	Requirements for the manufacturing and space qualification of all the pressurized weld joints in the AMS TTCS evaporator.	ASR-S-001,Rev. B	September 2003
RD-5	Process Specification for Automatic and Machine Arc Welding of Steel and Nickel Alloy Hardware	PRC-0010, Rev. C	February 2006

3 Identification of welds

Each HX contains 1 weld adding up to a total of 3 welds: 2 for the FM and one for the QM HX. The welds are done with only one type of weld, so only one kind of weld is to be qualified.
In the following pictures is shown the final assembly of the Primary and Secondary FM HX and the housing dimension and configuration during the final welding step.

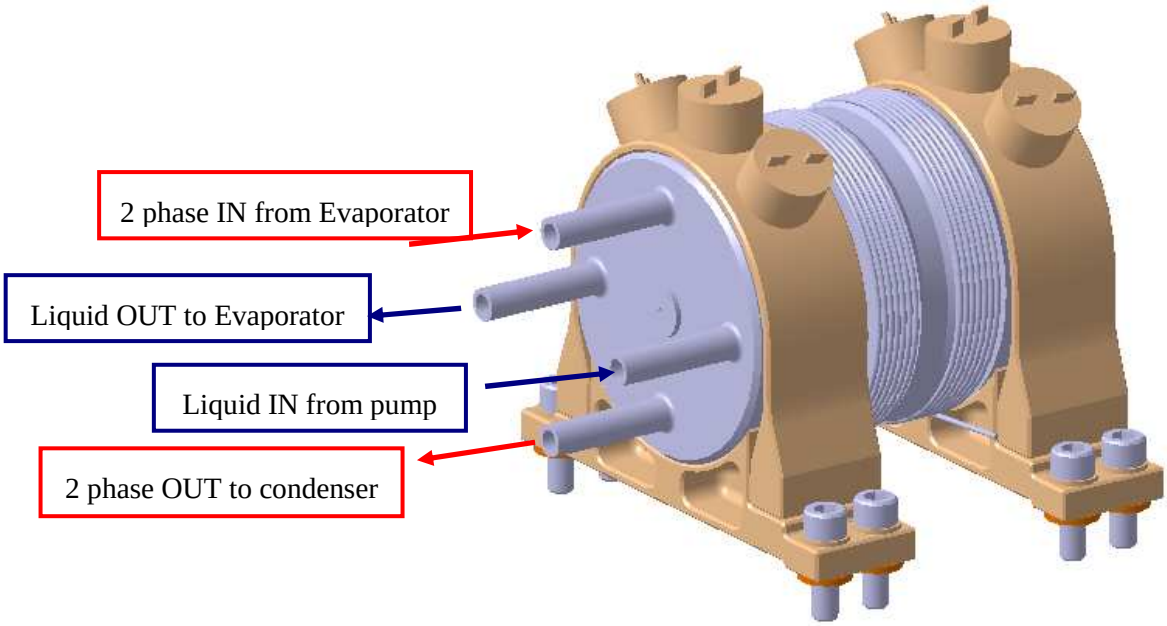


Figure 3-1. HX FM Primary overview

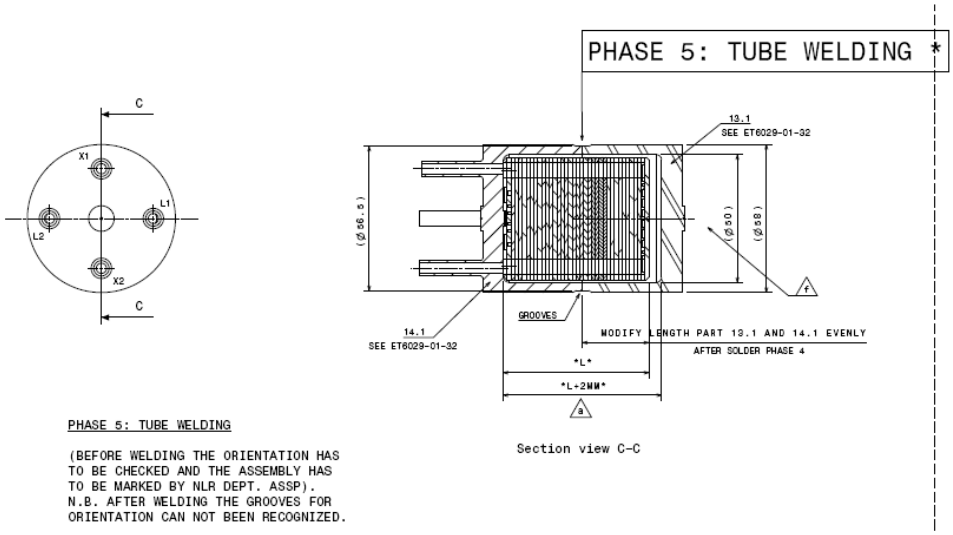


Figura 3-2. HX FM primary : orbital welding step (ref drawing: ET6029-04-DR-029-f-GE-ASM Heat exchanger welding and assemble)

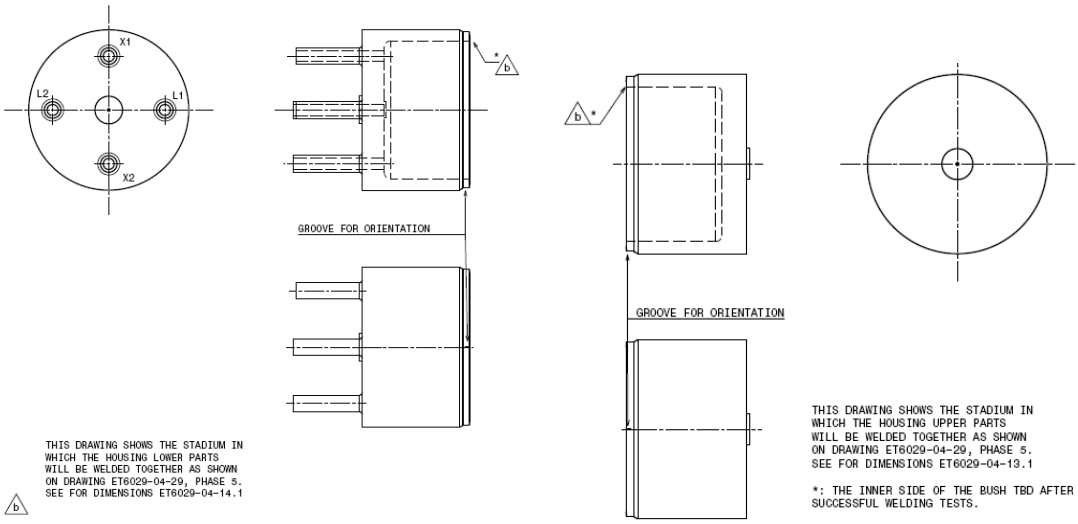


Figura 3-3. HX FM primary : housing configuration prior to orbital welding step (ref drawing: ET6029-04-DR-032-b-GE-ASM Heat exchanger part 13.1 and 14.1 before welding

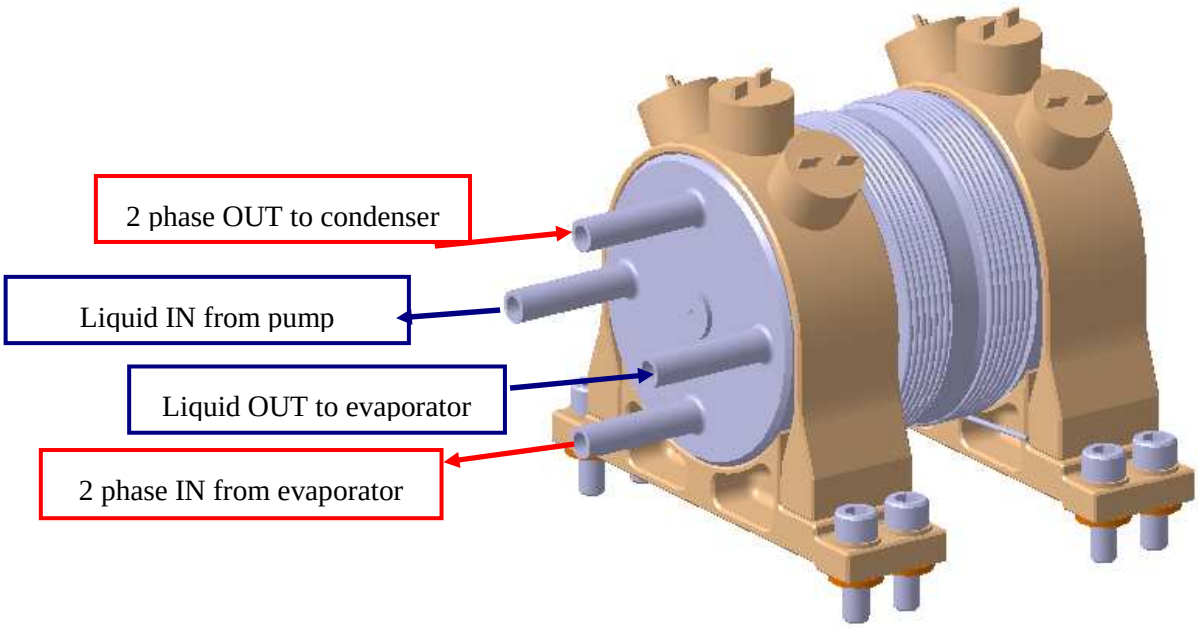


Figura 3-4. HX FM Secondary overview

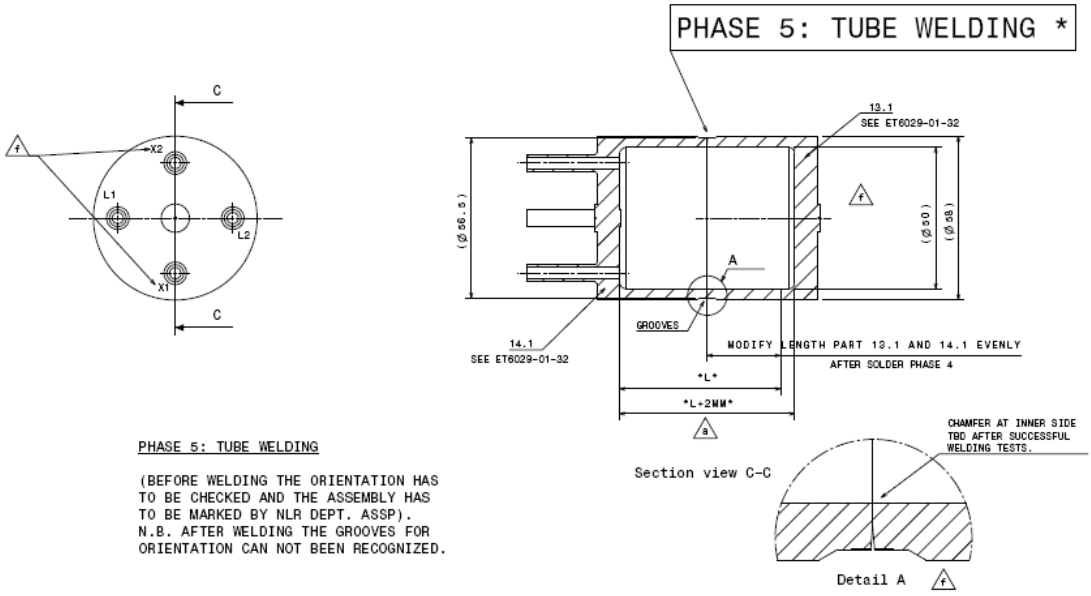


Figura 3-5. HX FM secondary : orbital welding step (ref drawing: ET6029-05-DR-029-g-GE-ASM_Heat_exchanger_welding_and_assemble)

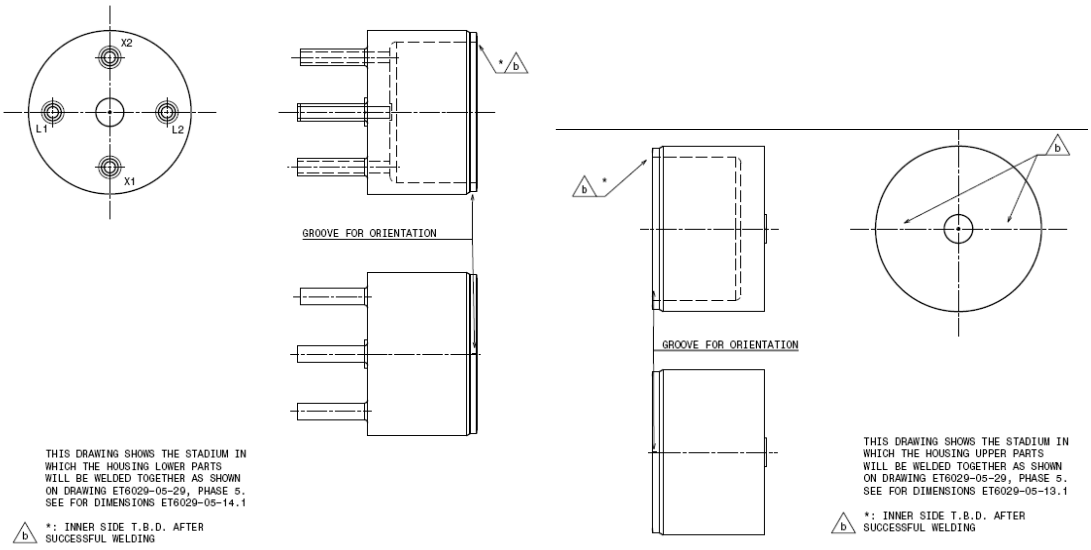


Figura 3-6: HX FM secondary : housing configuration prior to orbital welding step (ref drawing: ET6029-05-DR-032-b-GE-ASM Heat exchanger part 13.1 and 14.1 before welding)

3.1 Weld method and weld type used in HX

Welds are performed using flow-through protection gas. This method is straight forward and is described in section 8.2.

The weld type is only one, with dimension of 56.5 mm OD x 3.25 mm wall (as shown in Appendix B), made by a connection between two part of Inconel 625 of the same batch material. For this weld type a weld qualification programme is needed.

3.2 Class identification

All welds are classified as class B according to NASA document PRC0010. TTCS is a pressurised system and therefore class B requirements and methods for pressurised components are applicable.

4 Weld Schedule

The weld qualification and welding of the flight welds will be performed in the following sequence:

1. Weld sample tests for weld parameter definition
2. Weld Qualification on test weld samples (Q1 and Q2)
3. Weld sample testing and approval from NASA (Q1 and Q2)
    a. Radiographic inspection (see section 10)
    b. Visual inspection (see section 10)
    c. Check strength requirement for concavity (Appendix H)
4. Perform one (1) pre-welding sample
5. Welding of QM and FM flight welds
6. Perform testing on QM and FM's and pre-weld sample
    a. Radiographic (all)
    b. Visual inspection (all)
    c. He-leak test (QM and FM's)
    d. Proof pressure test (QM and FM's)
7. Perform welding sample welding for burst QB1
8. Perform burst test on QB1

The burst test will be performed after the flight welds as the margin for burst is extremely large and no negative result is expected (see also Appendix H).

5 Weld qualification

A weld qualification consists of the following steps:

- Identification of optimum weld parameters
- Weld qualification

The weld qualification is performed on a total of 2 weld samples. After agreement with NASA it was decided only two (2) samples at nominal setting are necessary for weld qualification. This is agreed in view of the few flight welds needed (2 FM and 1 QM).

All samples shall be send to NASA where they will be subjected to:

- Visually inspection to the Class B acceptance criterias in Appendix A.
- Liquid penetrant or magnetic particle inspection to the Class B acceptance criterias in Appendix A.

5.1 Standard Weld samples

The weld samples shall be cut in the same way as the flight hardware. A drawing of the weld sample for qualification is shown in Figure 5-1. To be underlined that a chamfer and a V-groove were foreseen to allow better penetration of the welding. The complete design drawing of weld sample is shown in Appendix B.

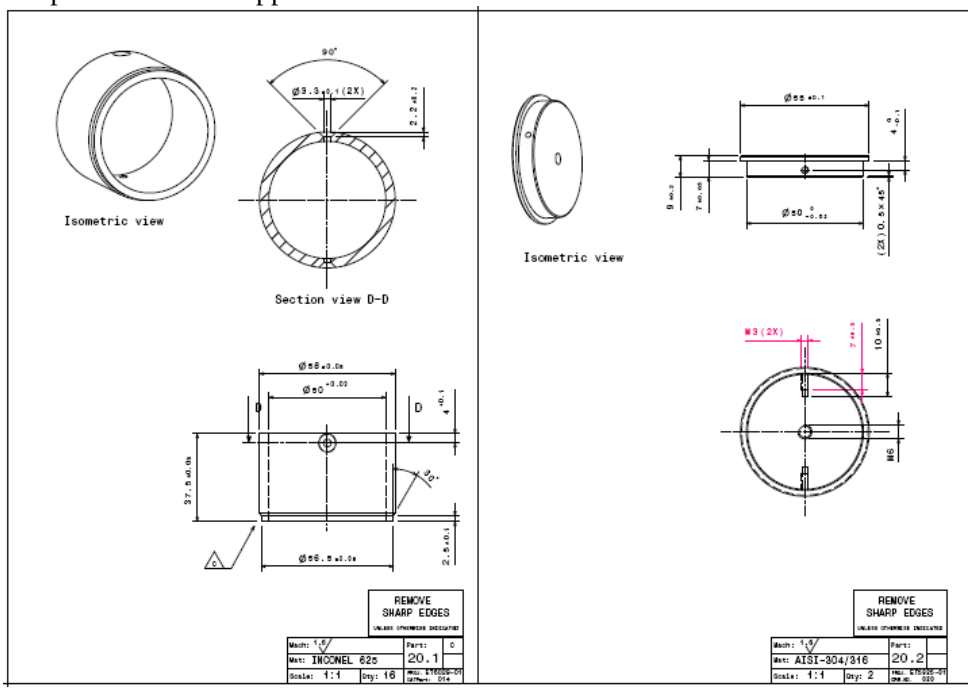


Figure 5-1: Qualification weld sample configuration (ref drawing: ET6029-01-DR-020-c-GE-ASM Heat exch welding test).

5.2 High , nominal and low heat input settings

The flight hardware welds shall be made with the nominal power setting. Common is to use a range of input settings with a variation in the order of ±10%, but this is no hard requirement. Using such a range is to deal with power fluctuations in the welding apparatus between the low and high limits and to accommodate a wider range of thickness variations.
These wide variations are not present in the few accurate machined parts for the HX welds.
Therefore it is decided in close consultation with NASA to perform qualification on 2 qualification samples (Q1 and Q2) at nominal settings.
After successful qualification and approval the 3 flight welds (1QM and 2 FM HX's) are performed.

5.3 Determination of the nominal weld parameters

After some unsuccessful tests performed with DC current, pulsed current was chosen as the best solution to achieve a good welding result. The NASA guidelines for pulsed current were followed, to find the optimum parameters (reported below) to achieve acceptable repeatability and weld quality:

Definitions:

- **Peak Current** = high current setpoint
- **Background Current** = low current setpoint
- **Pulsed current ratio** = ration of high current to low current setpoints; to be typically 3:1
- **PPS** = pulses per second (Hz); the pulse rate
- **Pulse width** = Percentage of time the weld program stays at the peak current setting in any one given cycle. The balance of the time will be spent at the low current setting.
- **Average current** = (% time of weld cycle)(peak current) + (% time of weld cycle)(background current)
- **Weld cycle** = period including one time segment at peak current + one time segment at background current
- **IPM** = Inches per minute; linear travel rate of the welding arc
- **RPM** = revolutions per minute
- **0.001**" = 0.0254mm

The guidelines in selecting the starting settings:

- **Weld current settings** - For PEAK current setting (high current) plan for about 1 amp for each 0.001" (0.0254mm) of wall thickness, for pure ARGON gas. If using an Argon/Hydrogen mix or Hellium/Argon, plan for about 0.7 amps for each 0.001" (0.0254mm) of wall thickness.
- **Weld current settings** - For BACKGROUND current setting (low current) plan for about 1/3 of the peak value selected (~3:1 ratio, peak to background)
- **Pulse width** - a good starting point is about 35% (or ~1/3) of the weld cycle
- **PPS** - Pulse as fast as is necessary to produce the desired result Each pulse actually produces a "weld spot." And it is preferable to overlap each spot at least 50% of the spot diameter to avoid between spot anamolies: setting the PPS will obviously be a function of the linear travel rate of the electrode to surface (e.g., if the travel speed is raised, the pps will have to be raised to achieve the same overlap).
- **Travel speed** - As a general rule, autogenous (no filler wire) weld schedules will typically function well in the range of 3 - 8 IPM (i.e., cm/min or mm/sec).
- The wall section (3.25 mm) is relatively thick so welding speed will likely be on the slow end which will compound the latent heat buildup problem. To combat this, it is recommended to divide the schedule into "levels" or "segments of the circumference" (e.g., every 60 or 45 degrees) to progressively step down in increments of heat input. Most orbital systems have this programming capability

Applying the above guideline to the HX configuration the following starting setting were found: (based on the above - INCO 625, 56.5mm O.D., 3.25mm wall thickness (0.001" = 0.0254mm):

1. Assume it will be a single pass weld, trying to limit high temperature excursions
2. Peak current = 0.7 x (3.25/0.0254) = ~90 amps
3. Background current = 90/3 = 30 amps
4. Pulse width = 35% at peak, 65% at background
5. 6 pps (selected arbitrarily from experience)
6. Select 3.0 ipm (76 mm/min) - Tube circumference = ~177 mm, rotational speed will then be 0.43 rpm (i.e., 76/177)
7. Total time for weld schedule will include the startup dwell time, circumference traverse time, and an area of overlap to fully consume your startup area. The dwell time at the start should be such that to just achieve full penetration through the wall thickness, and then travel (rotational motion) will start. This amount of time will be added to the entire schedule time.

The parameters were defined and can be found in the welding procedure sheets in section 12.

6 Welding procedure specification (WPS)

Process verification shall consist of visual inspection and/or (non)-destructive inspection, as described further in section 5 for weld qualification and section 7 for re-qualification. In addition, at the appropriate time during the fabrication activities, the following items shall be verified:

a. Verify that the welder is certified for the specific welding operation (prior to welding).
b. Fit-up in accordance with the engineering drawing (prior to welding for Class A Pressure Containing Components).
c. A WPS exists (prior to welding) see section 6.1.
d. Compliance with WPS for essential variable ranges (during welding).

6.1 Welding procedure specification (WPS)

The welding process shall be documented in a Welding Procedure Specification (WPS). The WPS shall be reviewed by NASA before the production of the actual flight and qualification H/W. An example WPS as will be used for HX welding is shown in Appendix D.

6.2 Welding Procedure Qualification Record (PQR)

Welding results (all qualification, re-qualification, post and pre-weld samples) shall be documented in a Procedure Qualification Record (PQR). An example PQR as will be used during flight qualification and flight welding is given in Appendix E.

7 Weld re-qualification

Re-qualification of welds will be performed in the following cases:

- The weld system has been placed on a different external power source except when the power supply has a means for internal power regulation,
- Major maintenance has been performed on the weld system. Major maintenance includes replacement of the power supply, major repair of the power supply requiring entrance into the controller or transformer cabinet, replacement of the weld head, or replacement or change in length of any of the interconnecting cables.

The weld re-qualification for the HX exists of the following step:

- Weld re-qualification

Weld settings	Number of welds	Examination
Nominal heat input settings	1	Visual Inspection Volumetric NDE (Non Destructive Examination)
Total	**1**	

Table 7-1: Qualification samples quantity overview

Re-qualification usually requires 3 samples, but for the HX case only 1 sample should be sufficient. The sample is subjected to visual inspection and volumetric NDE. Volumetric NDE can performed by either the radiographic method to the Class B acceptance criteria in Appendix A. The re-qualification results will be send electronically to NASA and to NLR for approval.
If the re-qualification activities result in any welding parameter(s) deviations that exceed the range specified in Table V of PRC0010 or AWS B2.1 as applicable, for that parameter, then the level of testing in section 5 is required. Table V is copied below.

Table V - Essential Welding Variables

Variable #	Variable / Weld Type	Range Allowed
1	Power Source Model #	None
2	Weld Head Model #	None
3	Joint Configuration	None
4	Groove Angle	+/- 5°
5	Nominal Tube Dia.	None
6	Nominal Wall Thickness	None
7	Material Type(s)	None
8	Electrode Start Position	+/- 60°
9	Preweld Cleaning Steps	None
10	Allowable Joint Gap	None
11	Tool or Shop Aid Identification	None
12	Preweld Purge Time	(1)
13	Postweld Purge Time	(1)
14	Tube ID Prepurge Flow Rate or Pressure	None
15	Weld Head Prepurge Flow Rate	+/- 15%
16	Plasma Gas Flow Rate	+/- 10%
17	Gas Composition/Spec.	None
18	Electrode Travel Speed & Machine Setting	None
19	Arc Travel Start Delay	None
20	Total Weld Current On Time	None
21	Weld Time @ Level or Circumference Interval	None
22	Current Pulse Width (%)	None
23	Current Pulse Rate	None
24	Filler Material / Spec.	None
25	Filler Wire Feed Speed	+/- 50%
26	Consumable Insert Type and Specification	None
27	Tubular Sleeve Spec.	None
28	Background Welding Current	None
29	Pulse Welding Current	None
30	Electrode Type	None
31	Electrode Diameter	None
32	Electrode Tip Geometry	None
33	GTAW Electrode to Work Gap (nom. setting)	+/- 10%
34	PAW Electrode Position Setting (nom. setting)	+/- 10%
35	PAW Orifice Size	None
36	Minimum Preheat Temp.	None
37	Maximum Interpass Temp.	None
38	PWHT Procedure/Spec.	None

Tabel 7-2: Essential welding variables

8 Welding during TTCS HX assembly

For welding of the HX the orbital welding with flow-through shielding gas is used.
In this section the general approach and preparations for the welding is given.

8.1 Orbital welding preparations

8.1.1 Cleaning and clean working

The welding and welding preparation of the HX parts will be performed in a class 100,000 or better clean room environment. The flight parts and flight weld samples are clean inside. Handling is focussed in avoiding contamination to get inside and keep the parts clean.
Cleaning should be done according to AMSTR-NLR-PR-056 FM HX Cleaning before welding procedure.

8.1.2 Pre-weld samples during assembly

In this particular case of HX welding, only a pre weld sample is required, to be performed in the same day of the flight welding.
The pre-weld is made according to the WPS and examined and documented in a PQR by Miaoh Tieh/AIDC. At the end, the filled procedures and PQR's are send to the NASA weld specialist and the TTCS project leader for review.

8.2 Standard orbital welding with flow-through shielding gas

The standard orbital weld method is used for the HX weld. The purge gas set-up is shown in Figure 8-1.

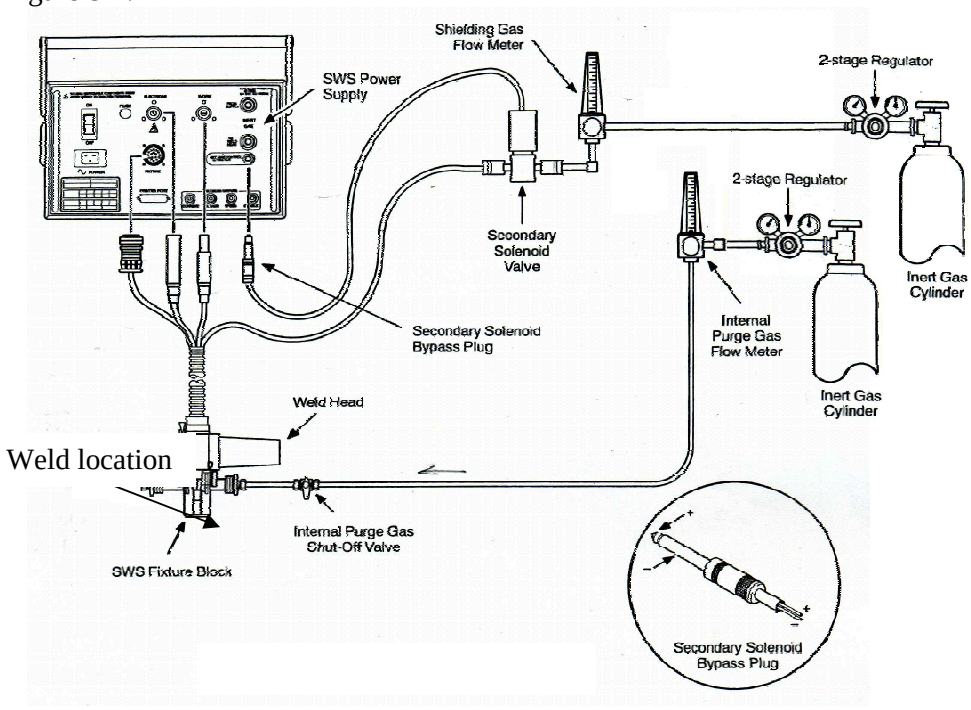


Figure 8-1: Purge gas set-up flow through

8.2.1 Main steps for welding with flow-through shielding gas

The main steps are:

1. Perform according to the applicable WPS in Appendix D.
    a. Clean the two part of the sample (drawing reference: ET6029-01-DR-020-c-GE-ASM Heat exchanger welding test) according to AMSTR-NLR-PR-056 FM HX Cleaning before welding procedure
    b. Spot weld tubes together (specify spot weld) and document weld parameters
    c. Use fixture to fix the parts in line
    d. Take picture of the test set-up
    e. Purge gas with DP gage before welding
    f. Perform welding

9 Weld facility description

The weld qualification, re-qualification and flight welding is performed at Miaoh Tieh in Taiwan and it uses the following equipment:.

- GAS: (Ar 97% + Hydrogen 3%)
- Purge gas set-up as shown in Figure 9-1
- Power: POLYSOUDE PS 204 (appendix F)
- Tungsten Electrodes: Torch electrodes shall be 2 % ceriated tungsten and meet the requirements of AWS A5.12 (not yet found).
- Weld head: 56.5mm OW115(ORBIMATIC) (Appendix F)
- Cleaning machine: SUPER STAINBRITE TK-909S (Appendix G)

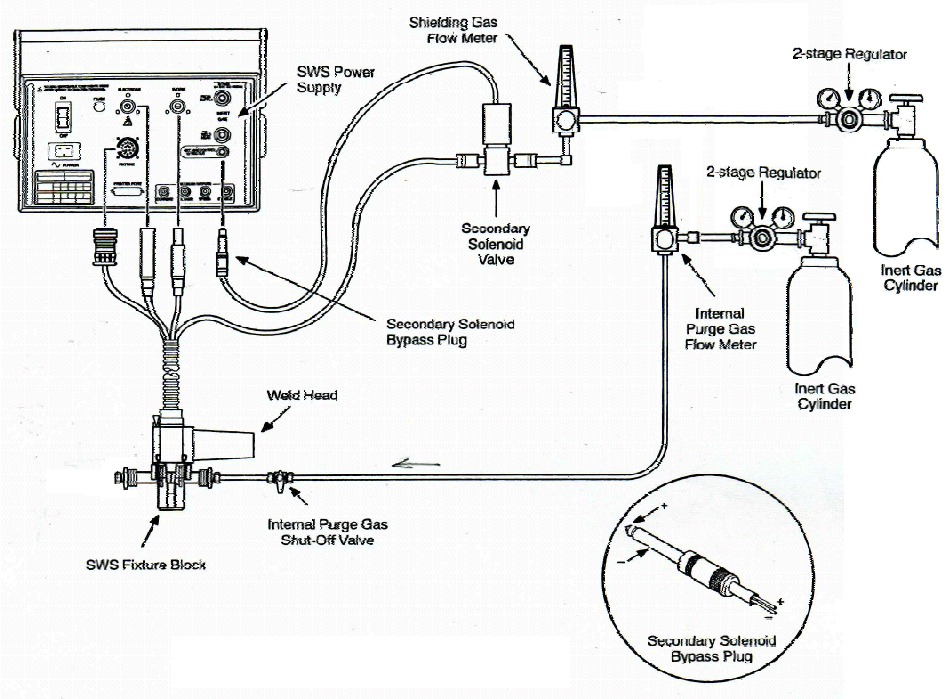


Figure 9-1: Miaoh Tieh Purge gas set-up

10 Main steps for welding schedule/procedure

The main steps are:

1. Perform qualification test samples according to the applicable WPS in Appendix D.
    g. Clean the two part of the sample (drawing reference: ET6029-01-DR-020-c-GE-ASM Heat exchanger welding test) according to AMSTR-NLR-PR-056 FM HX Cleaning before welding procedure
    h. Spot weld tubes together (specify spot weld) and document weld parameters
    i. Use fixture to fix the parts in line
    j. Take picture of the test set-up
    k. Purge gas with DP gage before welding
    l. Perform welding
2. Document the weld parameters in PQR as in Appendix E.
3. NDE and metallographic examination of weld samples
4. Flight weld preparations
    a. Document part numbers
    b. Check material traceability and certificates (see Appendix C)
5. Direct prior to the first QM/FM weld perform a pre-weld sample
    a. Use fixture to fix parts in line
    b. Purge gas with DP gage before welding
    c. Perform welding
6. Perform flight welding (1 x QM, 2 x FM)
    a. Use fixture to fix parts in line and/or components
    b. Take picture of weld set-up
    c. Purge gas with DP gage before welding (pay attention to direction)
    d. Perform welding
7. Perform testing on QM and FM's and pre-weld sample
    a. Radiographic (all)
    b. Visual inspection (all)
    c. He-leak test (QM and FM's)
    d. Proof pressure test (QM and FM's)
8. Perform welding sample welding for burst QB1
9. Perform burst test on QB1

11 Qualification and flight Welding procedure sheets

11.1 Qualification weld procedure sheets

	Welding Qualification procedure sheet		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
1.	Record Flight Model/Qualification Model Record Primary/Secondary		-			
2.	Record reference drawing number					
3.	Record welding method		Flow through			
4.	Record Weld Procedure Specification (WPS) issue & fill WPS for flow through welding					
5.	Record Weld Procedure Qualification Record (PQR)& prepare PQR for flow through welding					
6.	Prepare all samples for the total 2 qualification welds to identify the nominal limit input settings					
7.	Clean samples on inside and outside with IPA (Iso-Propyl-Alcohol) with clean cloth					

	Welding Qualification procedure sheet		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
8.	Clean fixtures and other tooling with IPA and cloth					
	Start welding					
9.	Use fixture to fix parts in line.					
10.	Make a picture of the weld set-up					
11.	Spot weld the two parts to fix them together. Carefully record the spot weld parameters and use this also for other QM and FM welds.					
12.	Purge shielding gas through the welds Add here a clear picture of purge inlet and outlet connection to be similar to the weld sample					
13.	Perform welding and fill PQR					
14.	Perform visual inspection to the Class B criterias in Appendix A. If the sample passes the visual inspection requirements continue with next step. If not discuss with welder how to proceed.					

	Welding Qualification procedure sheet		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
15.	Clearly mark the weld sample with Q1 and Q2, and store for further examination					
16.	Repeat steps 11-17 for all 2 qualification samples.					
17.	Check all samples are clearly marked and the WPS and PQR are available.					
18.	Make picture of samples indicating the marking and store electronically					
19.	Contact NASA on sample inspection planning					
20.	Repeat this sheet for all other flow-through welds.					
21.	End qualification sheet					

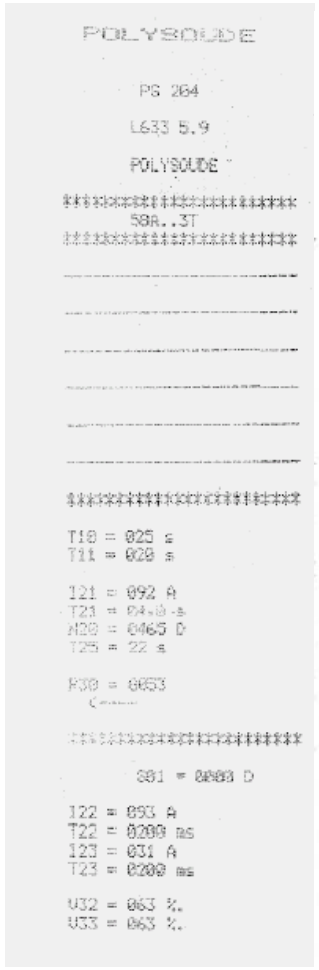
11.2 Flight and pre welding procedure sheets

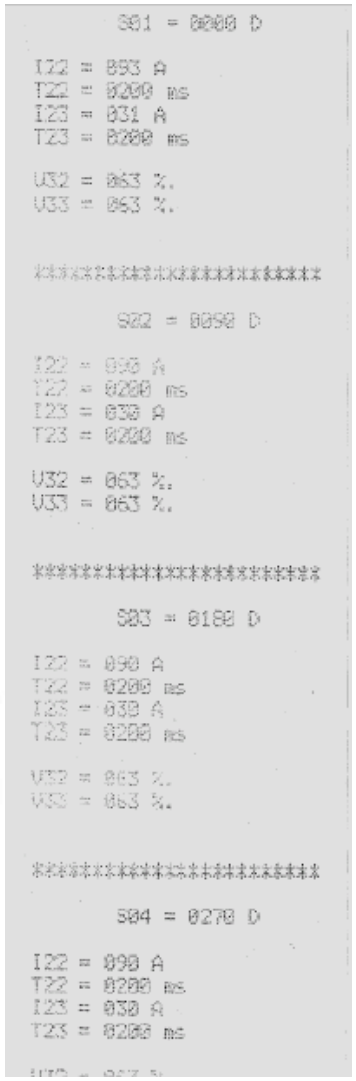
	Flight and pre-welding procedure sheet		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
1.	Record Flight Model/Qualification Model Record Primary/Secondary		-			
2.	Record reference drawing number					
3.	Record welding method		Flow through			
4.	Record Weld Procedure Specification (WPS) issue & fill WPS for flow through welding					
5.	Record Weld Procedure Qualification Record (PQR)& prepare PQR for flow through welding					
6.	Prepare all housing for the total 4 welds (pre-weld sample, QM, 2 x FM)					
7.	Check the HX parts are cleaned according to AMSTR-NLR-PR-056					

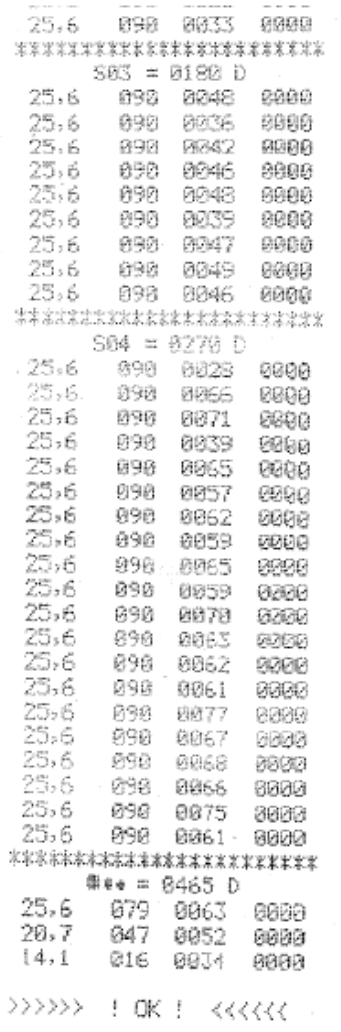
	Flight and pre-welding procedure sheet		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
8.	Clean the pre-weld sample housing, fixtures and other tooling with IPA and cloth					
	Start welding					
9.	Use fixture to fix parts in line.					
10.	Make a picture of the weld set-up					
11.	Spot weld the two parts to fix them together. Carefully record the spot weld parameters and use these parameters also for other QM and FM welds.					
12.	Purge shielding gas through the welds. Add here a clear picture of the right tube HX connection to be similar to the weld sample inlet and outlet connection and flow direction					
13.	Perform welding and fill PQR					
14.	Perform visual inspection to the Class B criterias in Appendix A. If the sample passes the visual inspection requirements continue with next step. If not discuss with welder how to proceed.					

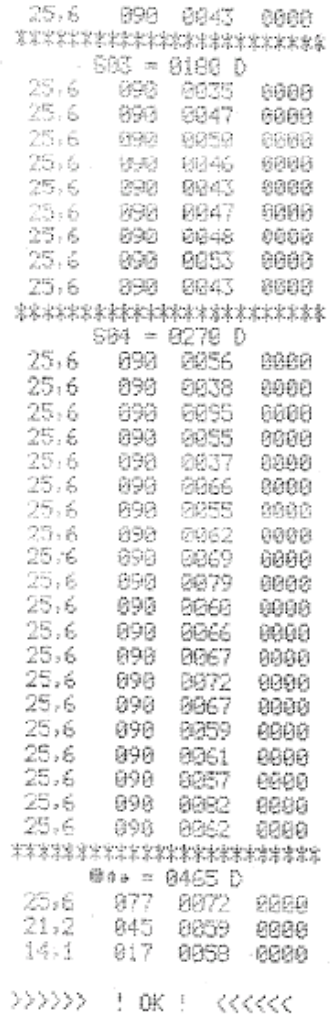
	Flight and pre-welding procedure sheet		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
15.	Clearly mark the weld sample with FM1/FM2/QM, and store for further examination					
16.	Repeat steps 11-17 for all 3 flight weld samples.					
17.	Check all samples are clearly marked and the WPS and PQR are available.					
18.	Make picture of samples indicating the marking and store electronically					
19.	Contact NASA on sample inspection planning					
20.	End qualification sheet					

12 Qualification Welding procedure record, visual inspection and radiographic results Qualification Welds (Q1 and Q2)

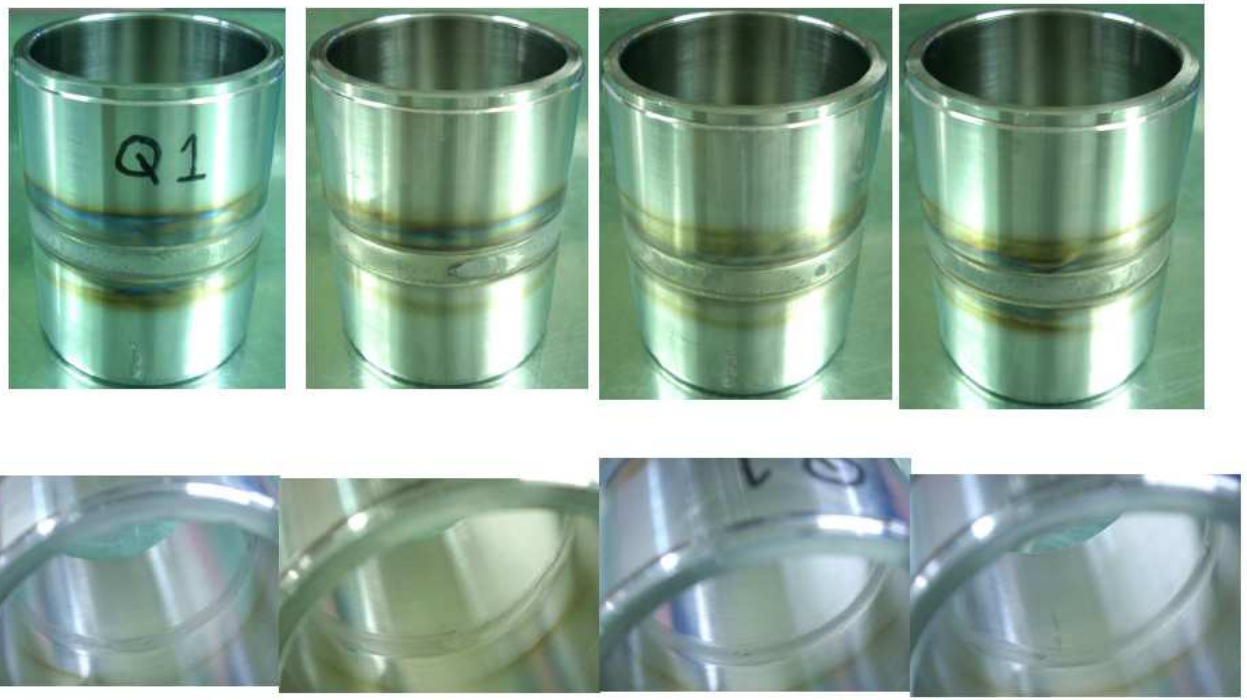






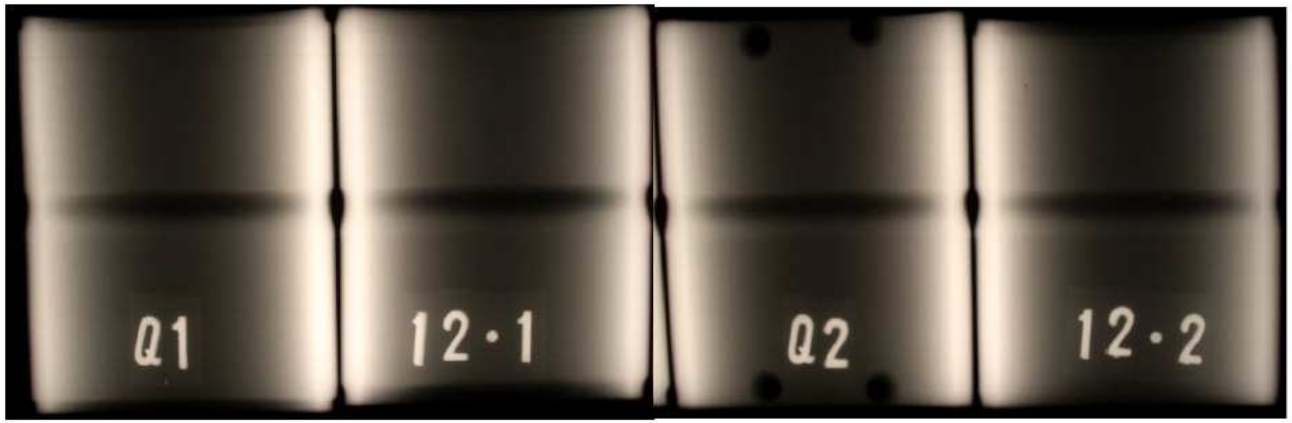


Qualification 1

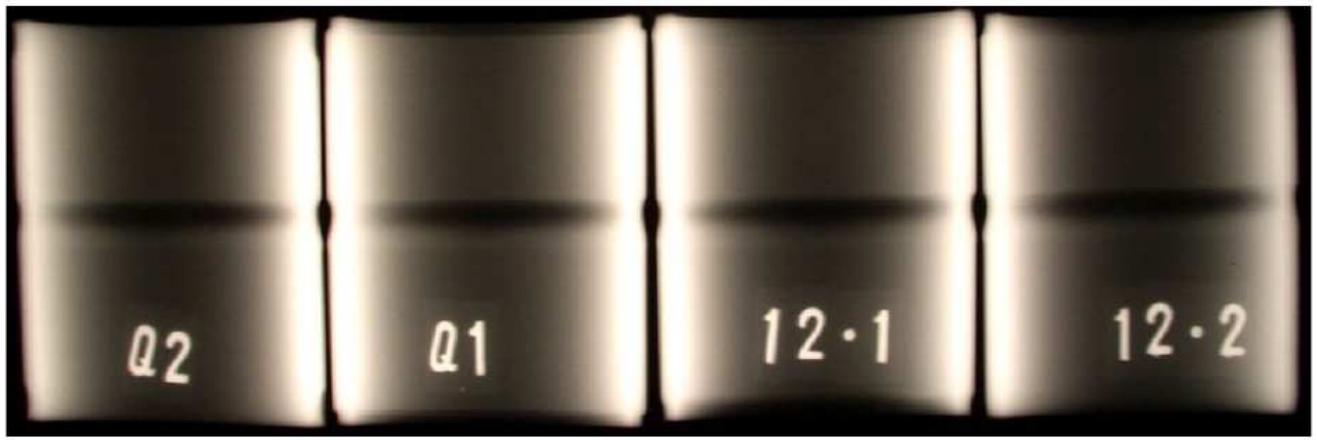


Qualification 2

X-RAY 0°



X-RAY 90°



Remark: In contradiction with below sheet a 2% ceriated tungsten electrode has been used not thoriated as written.

YOUR COMPANY/ORGANIZATION NAME goes here

Miao Tieh Precision Industrial CO., LTD.

ORBITAL TUBE ARC WELDING PROCEDURE SPECIFICATION (WPS)

WPS Number _____ Revision _____ Company / Organization _____

Supporting PQR no.(s) _____ Welding Process(es) Automatic Orbital Tube Gas Tungsten Arc

BASE and FILLER METAL :

Material number Q1 Group _____ to Material number _____ Group _____

Material spec., type, and grade Inco 625 to Material spec., type, & grade _____

Base metal thickness range 4mm, 3.25mm (Welding Area)

Pipe / Tube diameter 56.5 mm Wall thickness 4 mm

Filler metal F No. _____ AWS Class & Spec. _____

Consumable Insert, AWS Class & Spec _____

GAS : Before: Flow Rate: 10, 5 Min. After: Flow Rate: 15, 3 Min

Torch/Head gas(es) Ar + H2

% Composition 97% + 3% Flow Rate 12 + 2 (LPM)

Prepurge Time 25 Postpurge Time 20

Backing gas(es) Ar + H2

% Composition 97% + 3% Flow rate 3 (LPM)

Prepurge Time 25 Postpurge Time 20

WELDING SET-UP :

Power Supply (Model) PS204

Weld Head(s) OW115

Joint Position(s) _____

Tungsten type Thoriated Diameter 2.4mm Arc gap 1.2mm

Tip diameter 0.2 mm Tip angle 15°

Weld direction _____ Pulse Mode _____

PRE and POSTWELD HEAT :

Preheat temperature minimum _____

Preheat temperatue maximum _____

Interpass temperature minimum _____

Interpass temperature maximum _____

Postweld HeatTreatment _____

WELD SETTINGS :

Start current (amps) 92 Upslope (sec.) _____

Level Slope Time (sec.) _____ Downslope (sec.) _____

Start Delay (sec.) 4 Override (%) _____

Finish Current (amp) _____ Fixture Speed (RPM) _____

Weld Timer (on/off) _____ Step Mode (on/off) _____

Wire Mode (on/off) _____

JOINT DESIGN :

Joint type BUTT

Groove angle _____ Radius _____ Land _____

Root opening _____ Size of fillet _____

Socket weld pull-back _____

NOMINAL HEAT INPUT CONDITIONS :

SETUP SKETCH -

Level Number	Weld Time (sec.)	Allowable Current (amps) Settings HIGH +5%	HIGH Nominal	LOW -5%	LOW Nominal	Pulse Rate (pps)	Pulse Width Nominal
1	____	____	93	____	31	2.5	50%
2	____	____	90	____	30	2.5	50%
3	____	____	90	____	30	2.5	50%
4	____	____	90	____	30	2.5	50%

TECHNIQUE :

Remark: In contradiction with below sheet a 2% ceriated tungsten electrode has been used not thoriated as written

YOUR COMPANY/ORGANIZATION NAME goes here

Miao Tieh Precision Industrial CO., LTD.

ORBITAL TUBE ARC WELDING PROCEDURE SPECIFICATION (WPS)

WPS Number _____ Revision _____ Company / Organization _____

Supporting PQR no.(s) _____ Welding Process(es) Automatic Orbital Tube Gas Tungsten Arc

BASE and FILLER METAL :

Material number Q2 Group _____ to Material number _____ Group _____

Material spec., type, and grade Inco 625 to Material spec., type, & grade _____

Base metal thickness range 4mm, 3.25mm (welding Area)

Pipe / Tube diameter 56.5 mm Wall thickness 4 mm

Filler metal F No. _____ AWS Class & Spec. _____

Consumable Insert, AWS Class & Spec _____

GAS : Before: Flow Rate: 15 LPM, 8 Min. After: Flow Rate: 15 LPM, 3 Min.

Torch/Head gas(es) Ar + H2

% Composition 97% + 3% Flow Rate 12+2 LP

Prepurge Time 25 Postpurge Time 20

Backing gas(es) Ar + H2

% Composition 97% + 3% Flow rate 3 LPM

Prepurge Time 25 Postpurge Time 20

WELDING SET-UP :

Power Supply (Model) PS20K

Weld Head(s) OW115

Joint Position(s) _____

Tungsten type Thoriated Diameter 2.4 mm Arc gap 1.2 mm

Tip diameter 0.2 mm Tip angle 15°

Weld direction _____ Pulse Mode _____

PRE and POSTWELD HEAT :

Preheat temperature minimum _____

Preheat temperatue maximum _____

Interpass temperature minimum _____

Interpass temperature maximum _____

Postweld HeatTreatment _____

WELD SETTINGS :

Start current (amps) 92 Upslope (sec.) _____

Level Slope Time (sec.) _____ Downslope (sec.) _____

Start Delay (sec.) 4 Override (%) _____

Finish Current (amp) _____ Fixture Speed (RPM) _____

Weld Timer (on/off) _____ Step Mode (on/off) _____

Wire Mode (on/off) _____

JOINT DESIGN :

Joint type BUTT

Groove angle _____ Radius _____ Land _____

Root opening _____ Size of fillet _____

Socket weld pull-back _____

SETUP SKETCH -

NOMINAL HEAT INPUT CONDITIONS :

Level Number	Weld Time (sec.)	Allowable Current (amps) Settings HIGH +5%	HIGH Nominal	HIGH -5%	LOW Nominal	Pulse Rate (pps)	Pulse Width Nominal
1			93		31	2.5	50%
2			90		30	2.5	50%
3			90		30	2.5	50%
4			90		30	2.5	50%

TECHNIQUE :

Appendix A: Acceptance criteria for Class B pressure containing components

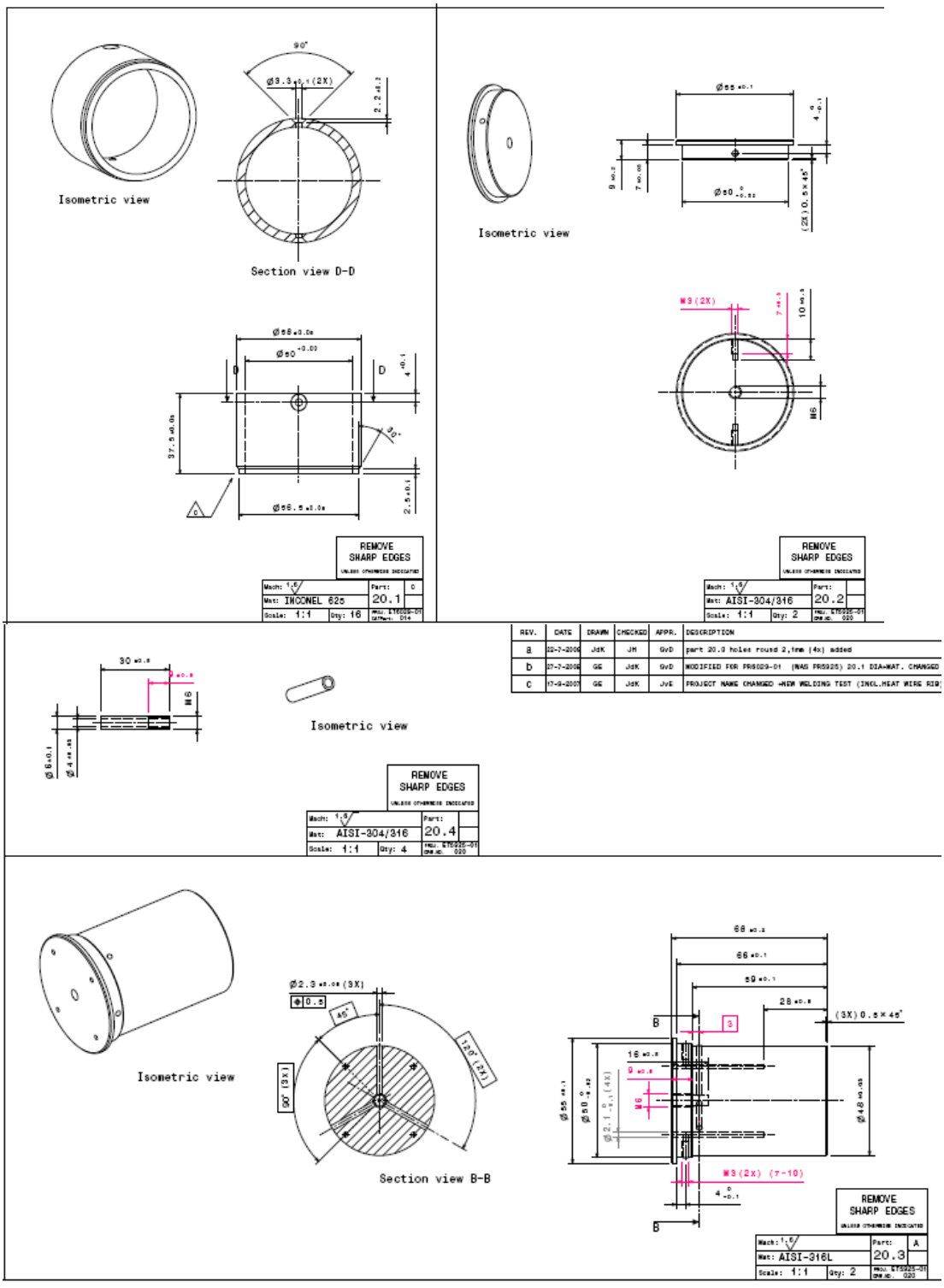
SURFACE INSPECTION ACCEPTANCE CRITERIA - CLASS B - Pressure Containing Components

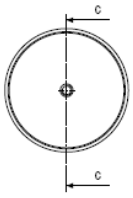
Size and Appearance of Groove Welds	Minimum size as specified on drawing. If profile requirements are not specified on the drawing, the weld shall be convex with a maximum reinforcement as stated herein. Any profile is unacceptable where the weld to base metal transition forms a sharp notch or reduces the base metal thickness (T) beyond the minimum specified on the drawing.
Size and Appearance of Fillet Welds	Minimum size as specified on drawing. If profile requirements are not specified on the drawing, the weld shall be flat or slightly convex with a maximum reinforcement as stated herein. Any profile is unacceptable where the weld to base metal transition forms a sharp notch or reduces (T) beyond the minimum specified on the drawing.
Cracks	None allowed.
Undercut	Undercut shall not exceed 15% of the total weld length. The depth of any undercut indication where T < 0.035", undercut shall not exceed 10% of T. Where T is >/= 0.035" and </= 0.09", undercut shall not exceed 15% of T or 0.010", whichever is the lesser. Where T > 0.09", the depth of undercut shall not exceed 0.015".
Pores or Voids	The maximum diameter shall not exceed 0.02" or 1/3 of T, whichever is the lesser. Indications less than .010" in diameter shall not be considered.
Weld Face or Root Concavity or WM Thinning	Concavity shall not exceed 15% of T or 0.015", whichever is the lesser.
Overlap	None allowed.
Misalignment	Misalignment shall not exceed 15% of T or 0.025", whichever is the lesser.
Peaking	Weld joint peaking shall not exceed a total of 5 degrees.
Weld Face or Root Convexity	Reinforcement, or melt-thru, shall not exceed 20% T or 0.06", whichever is the lesser.
Surface Discoloration	A black - brown color is not allowed.
Surface Roughness	Surface finish of welds and adjacent material resulting from processes used to remove weld reinforcement and otherwise shall not exceed 63 microinches.
General Workmanship	Weld deposits, face and root reinforcement and adjacent base metal shall display a smooth and uniform appearance. The weld toes shall blend smoothly into the base metal without unfused overlaps or undercut exceeding that specified.

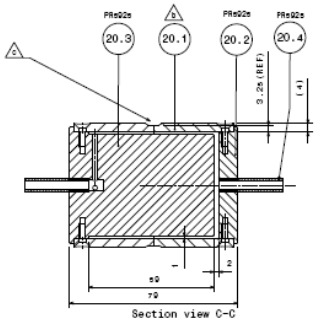
SUB SURFACE INSPECTION ACCEPTANCE CRITERIA - CLASS B - Pressure Containing Components

Cracks	None allowed.
Cold Shut and Laps	None allowed.
Porosity and Inclusions	The maximum diameter shall not exceed 0.02" or 1/3 of T, whichever is the lesser. Indications less than .010" in diameter shall not be considered.
Inadequate Penetration and Incomplete Fusion	The maximum length of any indication shall not exceed 1/3 of the T in any weld length of 6T or less. The minimum distance allowed between adjacent incomplete penetration or fusion indications, is ½ the length of the longest adjacent indication.
Undercut and Underbead Concavity	The length of any undercut or underbead concavity indication shall not exceed 15% of the total weld length. The depth of any undercut indication where T < 0.035", undercut shall not exceed 10% of T. Where T is >/= 0.035" and </= 0.09", undercut shall not exceed 15% of T or 0.010", whichever is the lesser. Where T > 0.09", the depth of undercut shall not exceed 0.015". The minimum distance allowed between adjacent undercut or underbead concavity indications is 1/2 the length of the longest adjacent indication.
Misalignment	Misalignment shall not exceed 15% of T, or 0.025", whichever is the lesser.
Weld Face or Root Concavity or WM Thinning	Thinning shall not exceed 15% of T or 0.015", whichever is the lesser.
Weld Face or Root Convexity	Reinforcement, or melt-thru, shall not exceed 20% of T or 0.06", whichever is the lesser.

Appendix B: Design drawing of weld samples (ref drawing:parts and assembly welding test ET6029-01-020-c-CCY)







WELDING TEST TOTAL 8X

WELDING TEST 1

PROOF WELDING PARAMETERS
PART 20.1 ; 20.2; 20.4 (2X)

WELDING TEST 2

PROOF WELDING PARAMETERS
AS TEST 1 WITH PART 20.3

WELDING TEST 3

PROOF WELDING PARAMETERS
AND TEMP. MEASURING (INFO FOR SLOLDER)
AS TEST 2 WITH THERMOCOUPLE

Appendix C: Material certificate

SPECIAL METALS

SPECIAL METALS WIGGIN LIMITED
Holmer Road, Hereford, England HR4 9SL
Tel: +44 (0)1432 382200 Fax: +44 (0)1432 264030
Reg. in England No. 36721

INSPECTION CERTIFICATE / ABNAHMEPRÜFZEUGNIS

Quality System Compliance :-
EN 10204/DIN 50 049 - 3.1.B
ISO 9001:2000 - AFAQ
ISO/TS 16949 (by agreement) - AFAQ
CAA (B2, Bel Approval No. AU2388/47
TUV Approval to AD - Merkblatt W0/TRD 100
RR5000 SABRe Approval No. 1604
For tests performed by IeceTest :-
ISO/IEC 17025 - UKAS, CAA (B4)

Certificate No. / Prüfbescheinigung-Nr. 1259954

Dated / Vom 21/09/2004

Page No. / Blatt Nr. 1 of 1

Consignee / Versenderanschrift

CONSIGNEE BY POST

統一發票專用章
統一編號
16462273
TEL:07-3413001
高雄市
左營區文府路287號

Customer's Order No. / Contract No. / Auftrag-Nr / Vertrag-Nr. 37004212

Inspector / Kontrolleur H35

Product Description & Dimensions / Prüfgegenstand, Werkstoff (Normbezeichnung) & Abmessungen
INCONEL alloy 625, Hot Finished Round, Machined, Annealed.
60.0 DIA MM RANDOM.

Our Reference No. / Kommission-Nr	Quantity / Stückzahl	Weight or Length / Gewicht oder Länge	Mill Batch No. / Los-Nr.	Cast No. / Schmelze-Nr.	Incoming Certificate No. / Eingangs-Prüfbescheinigung-Nr.	Advice Note / Bemerkhinweis
HTH0243/01	3	362 Kg	HTH0243/01	DLT3369		ASB09)

Specifications/Spezifikationen:
ASTM B 446 ISS 03 UNS N06625 | PACKING & MARKING TO BIBUS 10

Chemical Composition / Chemische Zusammensetzung
Weight % (except where stated ppm) / Gewichtsprozent (ausgenommen Angaben in ppm(Teile pro Million))

	C	Si	Mn	P	S	Al	Co	Cr	Fe
Bch	0.031	0.21	0.12	<0.005	<0.001	0.20	0.09	21.91	4.12
Top	0.03	0.23	0.11	<0.005	<0.001	0.22	0.09	21.99	4.08
Max	0.10	0.50	0.50	0.015	0.015	0.40	1.0	23.0	5.0
Min								20.0	

	Mo	Nb	Ti	Nb + Ta
Bch	8.66	69.6	0.31	3.60
Top	8.74	69.5	0.27	3.63
Max	10.0		0.40	4.15
Min	8.0	59.0		3.15

Test Report No. / Protokoll-Nr.
731220A

Mechanical Tests / Mechanische Prüfungen

Test Report No.	Temp. °C	0.2% PS MPa	Ten.Str. MPa	%Elong. on 4D
731220A	20	601	931	48.0

Heat treatment / Wärmebehandlung
Batch & test piece: 788 930 C AC

Other tests - remarks / Andere Prüfungen - Bemerkungen
Vacuum induction Melted & Electroslag remelted.
Castcode BTT.
Visual and dimensional examination satisfactory.
Primary cast number : DKL3324.
U.S.T. satisfactory to SI T-5004.
Positive material identification test satisfactory.

End of certificate / Ende

Certified that, unless otherwise stated above, the whole of the above-mentioned materials have been manufactured, tested and inspected in accordance with the terms of the contract/order applicable thereto and conform fully to the standards/specification quoted thereon and the requirements of.

Wenn nicht anders oben angegeben, wird bestätigt, daß alle oben erwähnten Materialien nach den Bedingungen des dafür gültigen Vertrages / Auftrages geliefert, geprüft und kontrolliert wurden und den darin angegebenen Normen / Spezifikation und den folgenden Vorschriften entsprechen

BS EN ISO 9001:2000

Signed
M.J.Pember
for and on behalf of SPECIAL METALS WIGGIN LIMITED
Authorised Signatory / Der Warenabnahmebeauftragte
M.J.Pember
Date 21/09/2004

Appendix D: Weld Procedure Specification (WPS) for standard orbital welding

MIAO TIEH PRECISION INDUSTRIAL CO., LTD

ORBITAL TUBE ARC WELDING PROCEDURE SPECIFICATION (WPS)

WPS Number _____ Revision _____ Company / Organization _____

Supporting PQR no.(s) _____ Welding Process(es) Automatic Orbital Tube Gas Tungsten Arc

BASE and FILLER METAL :

Material number _____ Group _____ to Material number _____ Group _____

Material spec., type, and grade _____ to Material spec., type, & grade _____

Base metal thickness range _____

Pipe / Tube diameter _____ Wall thickness _____

Filler metal F No. _____ AWS Class & Spec. _____

Consumable Insert, AWS Class & Spec _____

GAS :

Torch/Head gas(es) _____

% Composition _____ Flow Rate _____

Purge Time _____ Backup Time _____

Backing gas(es) _____

% Composition _____ Flow rate _____

Purge Time _____ Backup Time _____

WELDING SET-UP :

Power Supply (Model) _____

Weld Head(s) _____

Joint Position(s) _____

Tungsten type _____ Diameter _____ Arc gap _____

Tip diameter _____ Tip angle _____

Weld direction _____ Pulse Mode _____

PRE and POSTWELD HEAT :

Preheat temperature minimum _____

Preheat temperature maximum _____

Interpass temperature minimum _____

Interpass temperature maximum _____

Postweld Heat Treatment _____

WELD SETTINGS :

Start current (amps) _____ Upslope (sec.) _____

Level Slope Time (sec.) _____ Downslope (sec.) _____

Start Delay (sec.) _____ Override (%) _____

Finish Current (amp) _____ Fixture Speed (RPM) _____

Weld Timer (on/off) _____ Step Mode (on/off) _____

Wire Mode (on/off) _____

JOINT DESIGN :

Joint type _____

Groove angle _____ Radius _____ Land _____

Root opening _____ Size of fillet _____

Socket weld pull-back _____

SETUP SKETCH -

NOMINAL HEAT INPUT CONDITIONS :

Level Number	Weld Time (sec.)	Allowable Current (amps) Settings HIGH +5%	HIGH Nominal	HIGH -5%	LOW Nominal	Pulse Rate (pps)	Pulse Width Nominal
1							
2							
3							
4							

TECHNIQUE :

Joint cleaning _____

Other _____

We certify that this welding procedure and schedule were qualified in accordance with the requirements of NASA / JSC PRC-0010.

Prepared By _____ Org. _____ Date _____

Approved By _____ Org. _____ Date _____

Appendix E: Welding Procedure Qualification Record (PQR)

YOUR COMPANY/ORG name goes here

Page 1 of 2

ORBITAL TUBE GAS TUNGSTEN ARC WELDING PROCEDURE QUALIFICATION RECORD (PQR)

PQR Number _____ Revision _____ Company / Organization _____

Supporting WPS no.(s) _____ Welding Process(es) Automatic Orbital Tube Gas Tungsten Arc

BASE and FILLER METAL :

Material number _____ Group _____ to Material number _____ Group _____

Material spec., type, and grade _____ to Material spec., type, & grade _____

Base metal thickness range _____

Pipe / Tube diameter _____ Wall thickness _____

Filler metal F No. _____ AWS Class & Spec. _____

Consumable Insert, AWS Class & Spec. _____

GAS :

Torch gas(es) _____

% Composition _____ Flow Rate _____

Prepurge Time _____ Postpurge Time _____

Backing gas(es) _____

% Composition _____ Flow rate _____

Prepurge Time _____ Postpurge Time _____

WELDING SET-UP :

Power Supply (Model) _____

Weld Head(s) _____

Joint Position(s) _____

Tungsten type _____ Diameter _____ Arc gap _____

Tip diameter _____ Tip angle _____

Weld direction _____ Pulse Mode _____

PRE and POSTWELD HEAT :

Preheat temperature minimum _____

Preheat temperature maximum _____

Interpass temperature minimum _____

Interpass temperature maximum _____

Postweld Heat Treatment _____

WELD SETTINGS :

Start current (amps) _____ Upslope (sec.) _____

Level Slope Time (sec.) _____ Downslope (sec.) _____

Start Delay (sec.) _____ Override (%) _____

Finish Current (amp) _____ Fixture Speed (RPM) _____

Weld Timer (on/off) _____ Step Mode (on/off) _____

Wire Mode (on/off) _____ Finish Current _____

JOINT DESIGN :

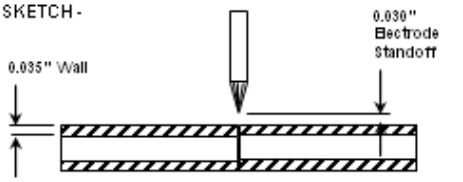
Joint type _____

Groove angle _____ Radius _____ Land _____

Root opening _____ Size of fillet _____

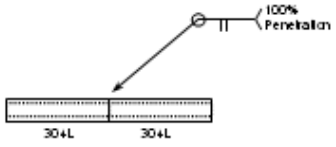
Socket weld pull-back _____

SKETCH -



NOMINAL HEAT INPUT CONDITIONS :

Level Number	Weld Time (sec.)	Allowable Current (amps) Settings HIGH +5%	Nominal	-5%	LOW Nominal	Pulse Rate (pps)	Pulse Width Nominal
____	____	____	____	____	____	____	____
____	____	____	____	____	____	____	____
____	____	____	____	____	____	____	____
____	____	____	____	____	____	____	____



TECHNIQUE :

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of the NASA / JSC PRC-0010.

Qualifier : _____ Reviewed by : _____

Date : _____ Approved by : _____

PROCEDURE QUALIFICATION RECORD (PQR) for ORBITAL TUBE GAS TUNGSTEN ARC WELDING

Page 2 of 2

PQR No. _____

TENSILE TEST SPECIMENS :

Type : _____ Tensile specimen size : _____ Area: _____

Groove ( ) Socket Lap w/fillet ( )

Tensile test results : (minimum required UTS : _____ psi)

Specimen No.	O.D., in.	Wall Thkns, in.	Area, in^2	Max Load, lbs	F_{tu}, psi	Type Failure/Loc

GUIDED BEND TEST SPECIMENS - SPECIMEN SIZE: _____

Type	Result	Type	Result

MACRO - EXAMINATION RESULTS :

_____

IMPACT TEST SPECIMENS

Type : _____ Size : _____

Test temperature : _____

Specimen location : WM = weld metal; BM = base metal; HAZ = heat - affected zone

Test results :

Welding position	Specimen location	Energy absorbed (ft. - lbs.)	Ductile fracture area (percent)	Lateral expansion (mils)

IF APPLICABLE — RESULTS

Hardness tests : ( ) Values	_____	Acceptable ( )	Unacceptable ( )
Visual Inspection ( )	_____	Acceptable ( )	Unacceptable ( )
Torque ( ) psi	_____	Acceptable ( )	Unacceptable ( )
Proof test ( ) Method	_____	Acceptable ( )	Unacceptable ( )
Chemical analysis ( )	_____	Acceptable ( )	Unacceptable ( )
Non-destructive exam ( ) Process	_____	Acceptable ( )	Unacceptable ( )
Other	_____	Acceptable ( )	Unacceptable ( )

Mechanical testing conducted by (Company) _____ Lab No. _____

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of the NASA / JSC PRC-0010.

Qualifier : _____ Reviewed by : _____

Date : _____ Approved by : _____

These forms are just for reference, non relevant issues can be deleted and applicable properties and tests shall be added.

Appendix F: Orbital welding equipment

Orbital Welding Equipment

ORBIMATIC SCHWEISSTECHNIK

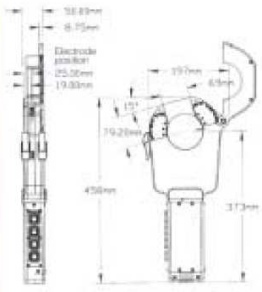
ORBIWELD, THE NEW ORBITAL WELDHEAD GENERATION WITH UNEXCEEDED FEATURES

- IN-HANDLE INTEGRATED REMOTE CONTROL
- QUICK-CHANGE SYSTEM FOR COLLETS
- HIGH DUTY CYCLE THROUGH HIGHLY EFFICIENT WATER COOLING
- COLLETS FOR NEARLY ALL STANDARD ELBOWS AND FITTINGS

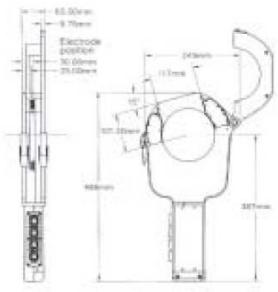
The closed chamber ORBIWELD heads are available in 3 different sizes:

ORBIWELD	65	for tube O.D.	6 – 65 mm
ORBIWELD	115	for tube O.D.	20 – 115 mm
ORBIWELD	170	for tube O.D.	50 – 170 mm

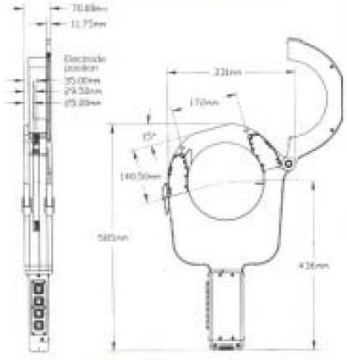
ORBIWELD 65



ORBIWELD 115



ORBIWELD 170



With the new ORBIWELD series ORBIMATIC has designed a weldhead range, which is distinguished by its high thermal load capacity. This development had been brought on by the changing requirements from the chemical, pharmaceutical, and food-processing industries. Now there are new applications with increased wall-thickness requiring more heat-resistant weldheads.

With specially designed water channels running completely throughout the whole weldhead body, a highly efficient heat exchange was created. This allows nearly continuous weld cycles even with high currents and high duty cycles.

The closed chamber design of the weldheads and the unique internal gas delivery system ensure a continuous non-turbulent gas shield around the whole weld joint resulting in minimal O.D. oxidation.

Another unique feature is the newly developed quick-changing system for the collets. No longer will you need any screws and tools for changing the collets! Without anything else, other than your hands, the collets can be easily snapped in or out of position while still ensuring proper, precise alignment of welded parts.

With a built-in integrated remote control in the rugged weldhead handle all critical welding commands can be transmitted to the power-source. This eliminates the need for an additional remote pendant.

Specifications subject to change without notice

ORBIMATIC SCHWEISSTECHNIK

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Appendix G: Cleaning equipment

SUPER STAINBRITE

MODEL **TK–909S**

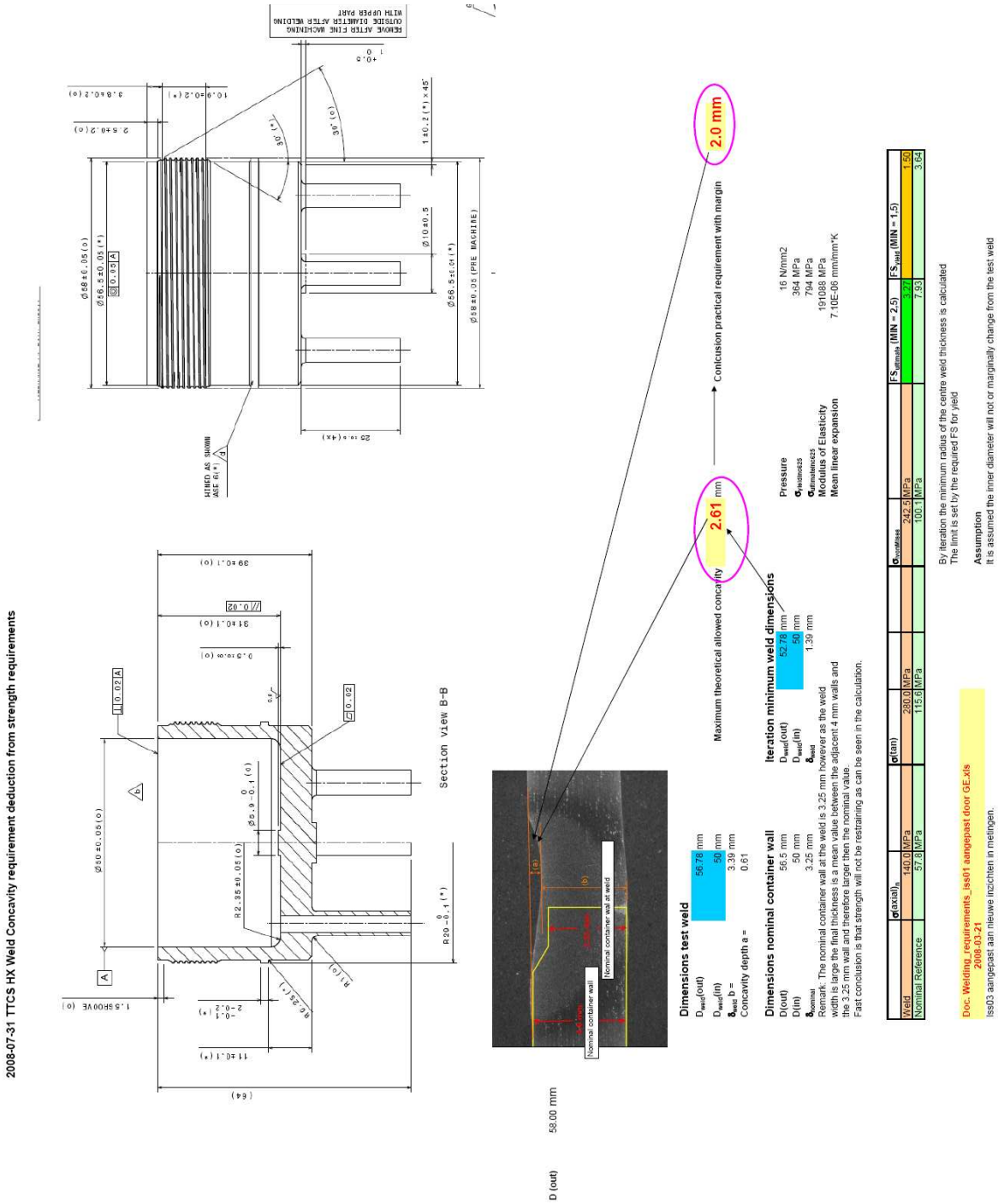
Provides a solution of your troubles ・・This One

SUPER STAINBRITE TK-909S is a lightweight, easy-to-handle portable surface-finishing unit.

SUPER STAINBRITE TK-909S shall be used with the following surface cleaning agent.

Removal of burning on the stainless steel.			
Chemical Agent	Purpose	Usage	Characteristics
STAINBRITE E-100	Ferrite system Stainless plate.	● Electrolysis unit. ● Dip the mop in the agent and torch on the surface finishing parts and rub on the surface. ● Wash by the water. ● Wipe out by the dry towel.	For all stainless steels materials. SUS403, 430, 304, 316,
STAINBRITE E-200	Stainless. General.		
STAINBRITE E-200E	No containing of Na, k		For electric equipment.
STAINBRITE -CL	Rust		For removal of rust
Removal of burning and electro-polishing.			
STAINLITE H-800	Stainless. Ti	● Use the acid ion electrolysis liquid.	For all stainless materials.
STAINBRITE E-500	Multipurpose		For all stainless materials.
STAINLITE Ti	Temper color	●Removal of stubborn burning.	Removal of temper color of Titanium.

Appendix H: Minimum weld thickness requirement (strength)



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